CONTROLLING INTERFERENCE CAUSED BY SECONDARY SYSTEMS

FIELD

[0001] The invention relates generally to mobile communication networks. More particularly, the invention relates to a mobile communication network where a secondary system shares radio resources with a primary system.

BACKGROUND

[0002] Modern wireless telecommunication systems aim to efficient utilization of the available frequency spectrum so as to maximize capacity and throughput. Multiple systems or sub-systems (underlay systems) may even be allocated to share a common frequency band. However, the operation of so-called secondary systems operating on the shared resources with primary systems needs to be controlled such that the interference from network elements of the secondary systems do not interfere the operation of the primary system.

BRIEF DESCRIPTION OF THE INVENTION

[0003] Embodiments of the invention seek to improve the efficiency of a network comprising a primary system and a secondary system sharing common resources.

[0004] According to an aspect of the invention, there are provided methods as specified in claims 1 and 13.

[0005] According to an aspect of the invention, there are provided apparatuses as specified in claims 18, 30 and 35.

[0006] According to an aspect of the invention, there is provided a computer program product as specified in claim 36.

[0007] According to an aspect of the invention, there is provided an apparatus comprising means configured to perform any of the embodiments as described in the appended claims.

[0008] Embodiments of the invention are defined in the dependent claims.

LIST OF DRAWINGS

[0009] In the following, the invention will be described in greater detail with reference to the embodiments and the accompanying drawings, in which

[0010] FIGS. 1A and 1B present a communication scenario and related example radio resource usage, respectively;

[0011] FIG. 2 shows a secondary user communicating with a secondary base station and causing interference to a primary user;

[0012] FIGS. 3 and 4 show methods according to some embodiments;

[0013] FIGS. 5 and 6 present apparatuses according to some embodiments;

[0014] FIG. 7 depicts signaling flow diagram according to an embodiment; and

[0015] FIG. 8 presents some simulation results.

DESCRIPTION OF EMBODIMENTS

[0016] The following embodiments are exemplary. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations of the text, this does not necessarily mean that each reference is made to the same embodiment(s), or that a particular feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

[0017] The scarcity of unoccupied radio spectrum is usually the bottleneck in high-speed wireless cellular and data networks. Cognitive radio is a rapidly emerging concept that seeks to improve spectral efficiency by allowing multiple radios to operate simultaneously in the same spectrum at the same geographic location. In such underlay systems with full frequency reuse, it is critical for the cognitive or secondary users (SUs) to limit the interference caused to incumbent or primary users (PUs) that are the licensed owners of the spectrum. Examples of underlay systems are device-to-device (D2D) networks coexisting with a cellular network, heterogeneous networks (HetNet) cells, such as femto- or picocells) that operate under the frequency reuse condition, and unlicensed users that operate in TV White Space spectrum (e.g., IEEE 802.22).

[0018] As said, the primary users of a primary system having a license to utilize the frequency may require seamless data transmission. For example, the TV broadcasters may need to have their transmission substantially free of interference. There are also other primary systems, such as wireless micro-phones, elements facilitating public safety, etc., which may require interference-free operation. However, when the frequency available for the primary users is not fully in use, the spectrum may be opportunistically used by the secondary users for wireless broadband data transmission, for example, without imposing severe interference to the licensed, primary users. There may be a database or an authorized shared access (ASA) approach applied when the secondary users aim in applying the common resources.

[0019] A general communication scenario to which embodiments of the present invention may be applied is illustrated in FIG. 1A. Referring to FIG. 1A, at least two systems are located such that their coverage areas overlap at least partly and that they may be configured to operate on a common frequency band. For example, a first system may be a cellular network or a television (TV) broadcast system. Let us assume that the first, primary system is a cellular network comprising a cellular base station 102 communicating with primary user terminals 104 on some channels of the common frequency band in a certain geographically limited area 100. The cellular network may operate for example according to at least one of the following radio access technologies (RATs): Global System for Mobile communications (GSM, 2G), GSM EDGE radio access Network (GERAN), General Packet Radio Service (GRPS), Universal Mobile Telecommunication System (UMTS, 3G) based on basic wide-band-code division multiple access (W-CDMA), high-speed packet access (HSPA), Long Term Evolution (LTE) and/or the LTE-Advanced (LTE-A) of the 3rd Generation Partnership Project (3GPP). In general, the first system may be any other system having a frequency band that may be shared with a second system and that may become fragmented through the frequency utilization of the first system.

[0020] The second system, which may be called a secondary system, a secondary user system or a system for users without priority with respect to frequency band, may be, for example, an ad-hoc D2D communication system where users communicate directly with each other, a broadband communication system, such as the worldwide Interoperability for Microwave Access (Wi-MAX), IEEE 802.11-based network (e.g. IEEE 802.11n, 802.11af, or 802.11ac), or IEEE 802.22-based network. The secondary system may comprise a net-